

plus, Dacryon, Colobostruma, Iridomyrmex, Notostigma, Camponotus and *Polyrhachis*. The fauna is probably smaller than that of the Thomas River depression and appears to share almost no species with the latter. It is further marked by having a much more distinct division between the diurnal and nocturnal elements. Several of the nocturnal sandplain species in *Colobostruma, Dacryon, Iridomyrmex* and *Camponotus* are notable for their very light coloration and large eyes, characteristics that are shared with *Nothomyrmecia macrops*. For this reason we consider it a strong possibility that *N. macrops* is nocturnal and a sandplain dweller.

In February 13-14, 1955, Athol Douglas and Edward Wilson collected in the arid eucalyptus forest from Norseman to Balladonia along the Transeontinental Highway. Other trips in the Norseman-Esperance-Balladonia area have been conducted independently by Athol Douglas, Tom Greaves and John Calaby. All of these efforts, like the ones before them, have been unsuccessful in finding *Nothomyrmecia*.

Few insect species have been the objects of such concentrated but consistently unsuccessful search as has the elusive *Nothomyrmecia macrops*. Because of its important phylogenetic position and our complete lack of information concerning its ecology and behaviour, its rediscovery and study in the living condition provide, in our opinion, one of the principal challenges of modern Australian entomology.

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COLOURING MATTERS FROM WESTERN AUSTRALIAN SUNDEWS II. THE RELEASE OF FREE PIGMENT.

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INTRODUCTION

The following description by Rennie (1887) of the occurrence of free pigment in *Drosera whittakeri* is apt and can be applied to related Western Australian sundews: "This species is provided with a tuber, one apparently to each plant, which is found attached to a straight stem at a depth of 3 or 4 inches. These tubers invariably consist of an inner solid but soft nucleus, full of reddish sap

or juice, and an outer series of easily detached thin and more or less dry layers of an almost black material. Between these layers is to be found small quantities of a brilliant red colouring matter, the amount varying in tubers of different size and age, but apparently more plentiful in the older plants."

An understanding of the manner in which the free pigment reaches this site has been obtained from a detailed study of the course of tuber formation in the related species *D. erythrorhiza* and the bulk of this paper is devoted to that subject.

From a study of *D. peltata* and *D. auriculata* collected near Sydney, Joyce W. Vickery (1933) established for the first time that the persistent layers of old tissue surrounding the tuber are not due to an onion-like (*viz.*: bulbous) growth or to an annual exfoliation but arise as the result of a special method of tuber replacement. They proved to be the remains, mainly epidermal, of old tubers which had experienced the withdrawal of all their reserve materials and had then been thrust aside and compressed against the wall of the soil cavity by each successive new tuber. Vickery's paper gives a detailed description of this process as seen in *D. peltata* and *D. auriculata*. For the present purpose we need only remember that in these species the new tuber forms alongside the current tuber, *viz.*: *externally*.

THE PROCESS IN *DROSERA ERYTHORHIZA*

In this Western Australian species an interesting variation occurs with the new tuber forming within the tissues of the current one.

The resting bud of the current tuber lies within a ring of seale leaves near the scar of attachment of the old stem. It shoots in early autumn to form a new stock and very early in this process the following significant events occur:

(i) within the ring of seale leaves on the current tuber the new stem swells basally, pressing the surrounding seale leaves outwards to form a funnel-like structure around the swollen base.

(ii) from a site on the under surface of this swollen base a bud descends within the funnel of seale leaves until it presses on the current tuber. At the same time the epidermis of the current tuber ruptures around the stem base allowing the descending bud to penetrate the living tissues of the current tuber where it inverts and swells to form a new tuber (see illustration).

In the absence of special provision for such an unusual event it might be expected that the new tuber would become deformed and the current tuber wither prematurely following the damage done to it, but the exposed ground tissue appears to degrade only at the rate needed to allow for gradual expansion of the new tuber.

This process of degradation or reduction occurs in two ways:

(i) by extraction of reserve materials through the intact connectives which continue to link current tuber and stem;

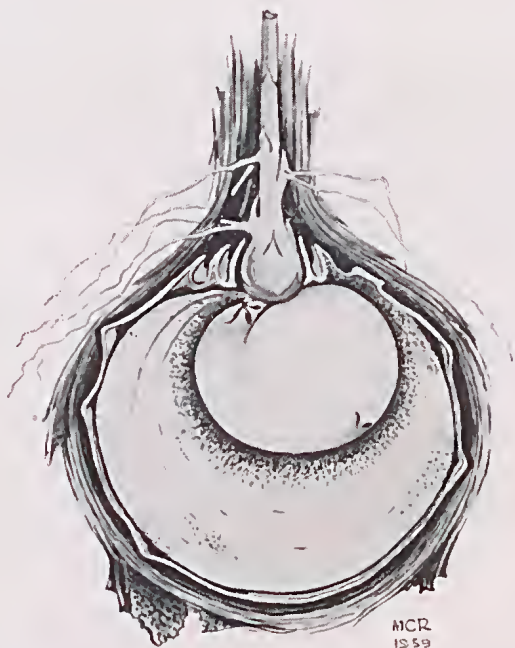
(ii) by autolysis of parenchyma cells at the exposed surface.

The first process leads to early shrinkage of the bulk of ground tissue and gives rise to a cavity beneath the epidermis. This is

shown in the illustration and is a feature of the process recorded by Vickery as seen in *D. peltata* and *D. auriculata*. It is probable that much of the nourishment stored in the current tuber finds its way to the new tuber during this reduction phase.

The second process, that of breakdown of exposed tissues, is the more important for the limited purpose of this paper and will be discussed more fully below.

The combined effect of these two processes finally exhausts the current tuber but not without a corresponding growth in the new tuber which ultimately occupies the space thus provided for it inside the envelope of persistent epidermis. When the last available remnants of reserve material have been withdrawn from stem and leaves the tuber then enters the resting phase to become the current tuber of the next season. In Vickery's terminology the exhausted remnants of epidermis and a few layers of parenchyma which now totally surround the resting tuber are referred to as the old tuber. That some parenchyma does remain can be shown readily by soaking the material in dilute sodium carbonate solution which serves to swell the tissues to something resembling their original turgid condition.



The perennating organ of *Drosera erythrorhiza* showing a new tuber developing in the living ground tissues of the current tuber which is drawn in section for the purpose of illustration (x 3).

This interesting process can only be appreciated fully in its uniqueness and its superficial but striking resemblance to a placental form of development by the study of a full range of living material but an attempt has been made to illustrate it by means of a "cut-away" diagram drawn from *D. erythrorhiza*.

RELEASE OF FREE PIGMENT

The purpose of this work was primarily to explain the origin of the red pigment described by Rennie (*l.c.*) and it is in the course of autolysis of the exposed parenchyma, immediately within the ring of scale leaves, that this substance first appears. This site of entry of the descending bud is the most exposed region of all and here a considerable concentration usually occurs in the form of a damp red plug. It is concluded from this that release of free pigment is a direct result of breakdown of the epidermis and exposure of the underlying cells. It is found in the same way in the tubers of *D. whittakeri*, *D. bulbosa*, *D. rosulata*, *D. stolonifera* and *D. zonaria*, all of which adopt this *internal* form of tuber replacement. Furthermore, in *D. heterophylla*, which was not previously known to form a red pigment, microscopic quantities were found around the initial rupture zone when a search was prompted by the discovery that this species also adopts the *internal* method of tuber replacement.

As the reduction phase progresses red pigment granules appear generally in the cavity beneath the epidermis and later they may be found scattered throughout the body of the current tuber. These scattered granules consist of small groups of cells in which pigment has concentrated to the extent that it solidifies in a red amorphous form or, rarely, as yellow needle-like crystals.

At the conclusion of this phase the pigment lies compressed between the swollen new tuber and the persistent epidermis of its predecessor and it is easily seen how annual repetitions of this process give rise to alternate layers of pigment and dried epidermis so characteristic of these tubers. Once these rather unlikely events have been seen it is easy to understand also why early workers, faced with dried and shrunk herbarium specimens, were unable to explain the process adequately.

BIOLOGICAL VALUE OF PIGMENT AND PROCESS

By careful dissection of a large *D. erythrorhiza* tuber I have counted twelve more or less complete layers together with remnants of others—a result strikingly reminiscent of Drummond's (1839) observation on *Glossodia* that "the bulb is renewed every year in the centre of several layers of bark-like substance, one of which layers is added every year by the decay of the old bulb. . . . The layers can be easily traced back for ten or twelve years, and I have no doubt that many of these Orchidaceae have continued to flourish in half a square inch of earth for ages." We may conclude with Drummond that "their numerous coats must be of the greatest use in protecting their roots from the excessive heat of the summer sun." The same may be said of the similar layers surrounding the tubers of *D. erythrorhiza* and its allies.

The biological role, if any, of the pigment poses a more difficult problem. However, one observation may have a bearing on this. At any stage during what I have referred to as the reduction phase the tissues of the current tuber have been found to be crisp and juicy with no obvious signs of invasion by soil micro-organisms. The plug of red pigment already mentioned may serve as a mechanical bar to their entry but whether it functions as an inhibitor or repellant is a matter on which there is so far no experimental evidence.

FREE PIGMENT IN *D. GIGANTEA*

The occurrence of hydroxydroserone in the flowers of *D. gigantea* has already been reported (1958), but it has since been found that a very much greater yield can be obtained from the seed capsules of the wilted plants collected in mid-summer. The pigment then occurs as a red powdery deposit inside the capsules and in microscopic quantities on the seeds and, in this respect, affords an interesting parallel with lomatiol, also a naphthaquinone, which has been reported (Rennie, 1895; Hooker, 1936) from the capsules and seeds of *Lomatia* spp. (Proteaceae) of Eastern Australia.

The external method of tuber replacement is adopted by *D. gigantea* but it differs from *D. peltata* and *D. auriculata* in that the old tissues are rarely persistent for more than one season resulting in an almost naked tuber. No free pigment is found on the tuber but it is nevertheless elaborated in the plant which shares with the red-tubered species an obvious need to remove the substance to avoid its concentration in the new tuber. In each case it appears to be an end-product of metabolism.

Identification of hydroxydroserone in *D. gigantea* was carried out by the method already described (1958) and gave a satisfactory melting point (190° C., corrected) as well as visible absorption spectra in the three solvents, light petroleum, 95% alcohol and dilute sodium hydroxide which could not be distinguished from those given in the same media by pure specimens from *D. whittakeri* and *D. erythrorhiza*.

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